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Black spruce decay in the Quebec boreal forest

André Lavallée

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RÉSUMÉ

La dissection de 5 981 épinettes noires (*Picea mariana* (Mill.) B.S.P.) en forêt boréale dans deux régions administratives du Québec a permis d'identifier les principaux champignons responsables des caries du pied et du tronc de cette essence. On note une plus grande fréquence et diversité de champignons lignicoles chez les caries du pied que chez celles du tronc. Par contre, ces dernières sont de 2 à 5 fois plus volumineuses que les caries du pied. Même si la proportion d'arbres affectés de carie du pied ou du tronc est équivalente à tous les étages du peuplement, le volume de ces caries était le plus important chez les arbres de l'étage supérieur du peuplement. En forêt boréale non perturbée et non aménagée, l'épinette noire présente un volume carié réel de l'ordre de 4 % du volume marchand brut lorsqu'elle atteint 23 cm au DHP ou 160 ans. Au delà de ces dimensions, le volume de carie s'accroît rapidement.

ABSTRACT

Dissection of 5 981 black spruce (*Picea mariana* (Mill.) B.S.P.) trees in the boreal forest within two Quebec administrative regions provided a basis for identification of the main fungi responsible for butt and trunk rot in this species. Observations indicate a higher incidence and greater diversity of xylophilous fungi associated with butt rot than with trunk rot. On the other hand, trunk rot volumes were 2 to 5 times larger than those of butt rot. Although the percentage of trees affected by butt or trunk rot is the same in all stories of the stands, the volume of decay was greatest among trees of the dominant story. In undistributed and unmanaged boreal forest, black spruce exhibits a real decay volume of about 4 percent of gross merchantable volume when it reaches 23 cm dbh or 160 years. Beyond these limits, decay volume increases rapidly.

INTRODUCTION

Under a national program of studies on decay in major Canadian forest species, many trees were dissected in Quebec between 1939 and 1957 and the identity and importance of decay-causing fungi were determined. Efforts were also made to establish reduction factors for estimation of losses attributable to rot in scaling.

For black spruce (*Picea mariana* [Mill.] B.S.P.), several publications resulted from similar studies conducted in Ontario (Morawski et al. 1958; Basham, 1973a and b). In Quebec, a brief summary of the situation at Duchesnay was published (Pomerleau and Morais 1941) and an unpublished internal report[1] presents the results of work carried out to the north of Baie Comeau in the Manicouagan central basin. Other areas of the province were also studied, but the results were not published.

Within the province of Quebec, the gross merchantable volume of trees in the "spruce" category is estimated at 1 780 million m^3 (Bonnor 1982), or 44 percent of the total volume produced in commercial forest (MER 1984). Since black spruce is a major component of the "spruce" category, any local information on the volume of rot affecting the species is of practical value. Accordingly, we reexamined the data base generated by these studies of black spruce decay in Quebec in order to extract the information most relevant to the users of this species.

METHODS

Field procedure

Black spruce from the boreal forest were dissected in the following areas (Figure 1.)

1- Baie-Comeau (Manicouagan and Toulnoustouc River basins) and Shelter Bay (Sainte-Marguerite River basin);
2- Laurentides Park (Noire, Jacques-Cartier, Sainte-Anne, Aux Écorces, and Malbaie River basins);
3- Charlevoix (Du Gouffre River basin).

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[1] Pomerleau, R.; Morin, L. 1959. Losses from decay in conifer stands in the Manicouagan watershed. Can. Dept. Agric., For. Biol. Lab. Quebec. Qué., Interim Report 1959-1, 11p.

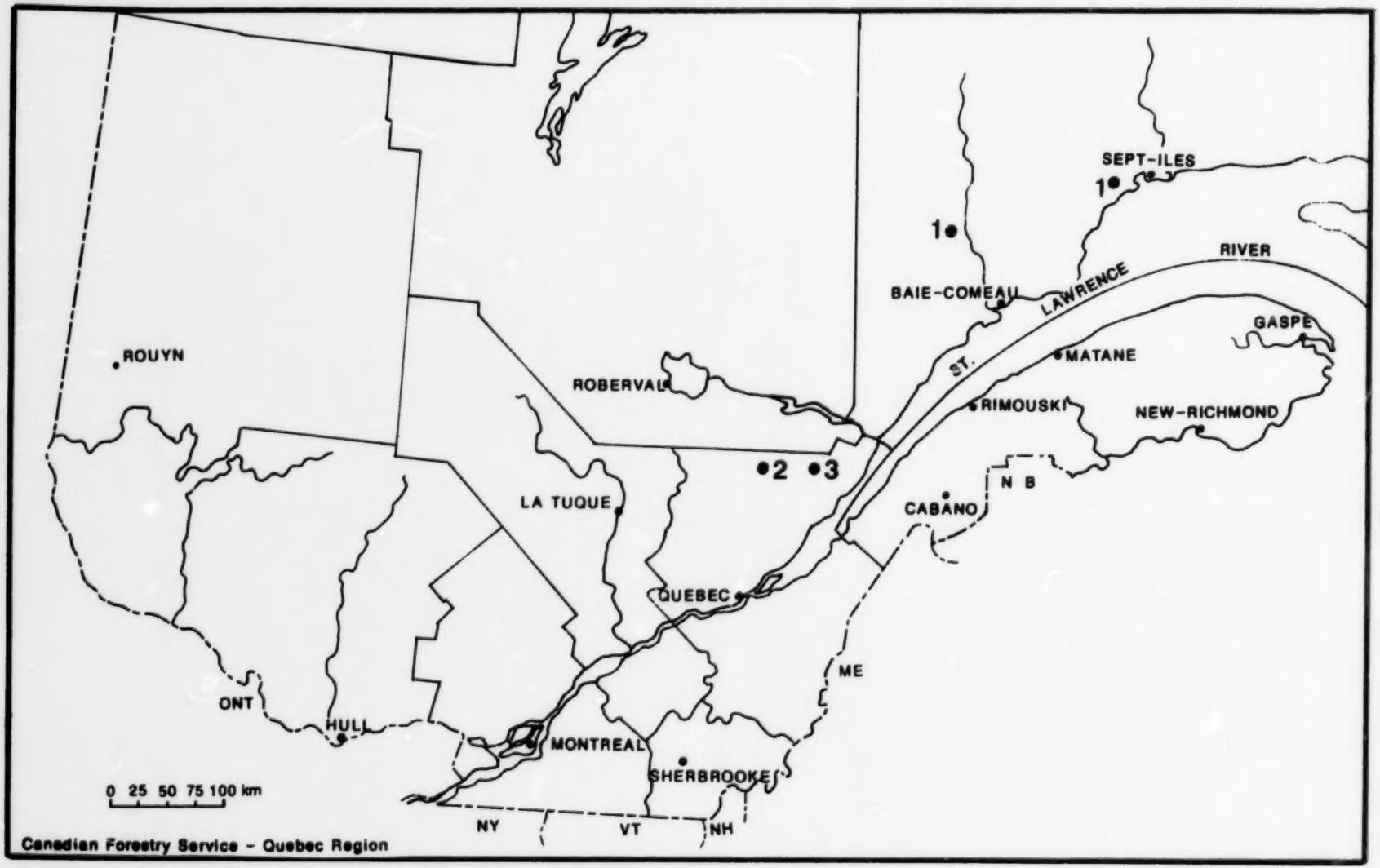

Figure 1. Location of black spruce decay study sites.

Two other study sites (Trécesson Township in the Abitibi region and Duchesnay in Portneuf County) were considered, but the number of trees at these locations (176 and 267 respectively) was deemed insufficient to permit valid comparisons. These sites are therefore not included in the present report.

Throughout the studies conducted between 1939 and 1944 and in 1966 and 1957, measurements were taken in the same manner. Sample plot selection was made on the basis of arborescent vegetation representative of the adjacent forest and herbaceous vegetation determining forest type. The latter was classified according to Bellefeuille (1932), Ray (1941), Linteau (1955), and Lafond (1956), permitting assessment of fertility and drainage characteristics of the sites. The stands had not been affected by major disturbances (fire, insects, cutting, etc.) in the 8 or 10 years preceding the studies.

Most sample plots were rectangular with an area of 0.1 ha (0.25 acre). A few were square with an area of 0.04 ha (0.1 acre). Except at Baie-Comeau, where trees were cut selectively accordingly to diameter for a given forest type, all sample plots were clearcut.

The story of the live tree and signs indicating infection courts of decay were noted. Trees over 9 cm (3.5 in.) in diameter at breast height (dbh, at 1.3 m above ground level) were cut 15 cm from the ground and sectioned into lengths of 1.2 m (4 ft.). The following measurements were taken: total length, diameter at half-tree height in order to calculate form class, merchantable length (to a diameter of 7.6 cm (3 in.)), and diameter outside and inside bark at each end of the bolt. Tree age was determined by the number of annual rings at breast height.

When rot was present, its diameter was noted at the ends of the bolts and, if necessary, the bolt was cut lengthwise to obtain the exact extent of the rot column. The decay was then quantified as "cull" according the Quebec Department of Lands and Forests scaling regulations then in effect. Current cull measurements would be slightly lower in view of changes made to the pulpwood scaling regulations over the last 25 years. A sample of each rot was collected and sent to the laboratory for culturing on an agar (2 percent) malt extract (1.5 percent) medium and subsequent identification.

Data analysis

a) Compilations

The total volume of the tree was obtained by adding the butt volume (cylinder formula), the volume of the non-merchantable part of the trunk (diameter less than 9 cm (cone formula)), and the volume of the merchantable part of the trunk. The last component was calculated using Newton's formula for each 1.2-m bolt:

$$V = (B + 4Bm + b)\frac{L}{6}$$

where V = volume, L = length, and B, b, Bm = cross-sectional area at the large, small ends and mid-section of the bolt.

Decay volumes were calculated similarly (Newton's formula and cone formula) since the exact length and diameter of decay were known for each bolt.

Volumetric results are presented first in a compilation of basic field data and then as values estimated from curves. In view of the data available, the curves in relation to dbh were obtained from the polynomial and exponential equations presented below. The correlation coefficients (R^2) for these curves range from 0.97 to 0.99 and the standard error of the estimate was 2.531 for GMV, 13.03 for DV, and 18.82 for CV with seven degrees of freedom.

Gross merchantable volume

$GMV = 36.5 - 13.0\ X_1 + 1.29\ X_2$

Decay volume

$DV = 0.0001\ X_1^{3.67956}$

Cull volume

$CV = 0.0028\ X_1^{2.88143}$

where X_1 and X_2 = dbh and dbh^2

Since all measurements were taken in Imperial units, calculations were made on that basis and results converted to metric units for presentation.

b) Variables

The data were first analysed in relation to forest types. In most cases, however, it was felt that there were insufficient associated repetitions within a given locality or from one locality to another and an attempt was made to compare fertility and drainage classes. A few trends were then detected, but the main results were grouped in terms of the boreal forest on the north shore of the St. Lawrence River.

Black spruce was present in 75 study plots--as a major component in 60 plots and as a companion species in the others.

Table 1 shows the distribution of tree studies according to locality, forest type, and fertility and drainage class. This table also illustrates the nonsystematic distribution of the sampling, which disallows a number of comparisons of regional characteristics.

RESULTS

Decay causing fungi

By culturing each decay sample collected during dissection, it was possible to identify the principal fungi that infect the trunk or butt of black spruce in natural forest.

Table 1. Distribution of number of black spruce trees studied at each locality according to forest type and soil fertility and drainage class

Forest type	Fertility[a]	Drainage[b]	Number of trees			Total
			Boreal forest			
			1	2	3	
Lycopodium - Cornus	I	M	160			160
Calliergon - Vaccinium	II	G	159	1 805		1 964
Calliergon - Cornus	II	G	268			268
Calliergon - Oxalis	II	G		97		97
Hylocomium - Cornus	II	M	649		741	1 390
Calliergon	II	M	745			745
Hypnum - Cornus	II	M		786		786
Hypnum - Hylocomium	II	M		2		2
Hylocomium - Oxalis	II	M		29	47	76
Sphagnum - Oxalis	II	P		21		21
Calliergon - Ledum	III	G	189			189
Calliergon - Kalmia	III	G	240			240
Kalmia - Vaccinium	III	G	43			43
Total			2 453	2 740	788	5 981

[a] Fertility I to III, very good to poor.

[b] Drainage: good (G), moderately good (M), poor (P)

a) Location, incidence, and relative importance

Table 2 shows higher incidence and greater diversity among fungi responsible for butt rot than among those responsible for trunk rot in black spruce in the boreal forest. Butt rot was primarily caused by the action of *Poria subacida* (Pk.) Sacc. at all locations studied. In locality 1, *Corticium galactinum* (Fr.) Burt. was mainly reported but, at the time, this fungus was often confused with *Poria subacida* (White 1951). *Polyporus tomentosus* Fr. is also a major contributor to butt rot in black spruce.

Among trunk rot fungi, *Fomes pini* (Thore ex Fr.) Karst. was most frequently encountered in all localities. *Stereum sanguinolentum*, subsequently known as *Haematostereum sanguinolentum* (Fr.) Pouzar, ranked second.

The volumes of decay resulting from the action of the main xylophilous fungi detected during these studies are presented in Table 3. This table lists results for all localities, since the relative incidence of the fungi shows practically no variation from one location to the next (Table 2). It can be seen that the average decay volume caused by *F. pini* is much greater than that produced by the two other main trunk rot fungi (Table 3). The first two trunk rot fungi (*F. pini* and *S. sanguinolentum*) are responsible for 94 percent of the incidence of this type of decay and cause 98 percent of trunk decay volume in black spruce. Among butt rot fungi, *P. tomentosus* produced the highest average decay volume even though it ranks second in terms of incidence.

b) Infection courts

The main points of entry into the trunk for *F. pini* were broken branches (53 percent) and mechanical wounds and abrasions (22 percent). For *S. sanguinolentum*, they were mechanical wounds and abrasions (48 percent), broken branches (30 percent), and frost cracks (9 percent). With butt rot, origin was attributed to root breaks and wounds in 87 to 98 percent of cases. It is interesting to note that, for *P. tomentosus*, wounds at the base of the tree (7 percent) and frost cracks (4 percent) were also associated with this type of decay.

Relative incidence of different infection courts varied little from one locality to the next except that a higher incidence of broken branches was noted in Laurentides Park (locality 2).

Table 2. Distribution of fungi causing black spruce decay at three boreal forest localities

Decay type and fungus	Incidence in % by locality			Percentage of total
	1	2	3	
Trunk rot				
Fomes pini[a]	9.9	31.9	6.2	18.3
Stereum sanguinolentum	9.0	13.1	5.4	10.1
Fomes pinicola[a]	1.4	2.4	0.3	1.5
Polyporus abietinus[a]	0.1	0.3	—	0.2
Stereum chailletii	0.3	—	—	0.1
Butt rot				
Poria subacida and/or *Corticium galactinum*[b]	30.8	35.7	36.2	34.7
Polyporus tomentosus	30.9	11.0	32.6	23.4
Polyporus balsameus	4.4	1.1	2.4	2.4
Coniophora puteana	3.3	—	3.3	1.7
Polyporus schweinitzii	0.3	3.5	—	1.3
Omphalia campanella	1.5	—	—	0.5
Polyporus borealis	0.3	—	0.3	0.2
Merulius himantioides	0.3	—	—	0.1
Peniophora sp.	0.1	—	—	0.1
Trechispora brinkmannii	0.1	—	—	0.1
Other basidiomycetes (ident)	1.0	0.7	0.3	0.8
Unidentified basidiomycetes	6.3	0.3	13.0	4.5
	100	100	100	100

[a] Occasionally butt rot. [b] Confusion between these two species may have occurred over the years of the study.

Table 3. Incidence and volume of decay caused by the main xylophilous fungi isolated in black spruce (all localities)

Fungus	Incidence of decay	Decay volume (m^3)	Average volume (dm^3)
Trunk rot			
Fomes pini	323	20.4	63.2
Stereum sanguinolentum	178	3.4	19.1
Fomes pinicola	27	0.4	14.8
Butt rot			
Poria subacida and/or *Corticium galactinum*	609	5.9	9.6
Polyporus tomentosus	411	4.9	12.0
Coniophora puteana	32	0.2	4.7

The average volume of decay from split crotches (50 dm^3 per wound) is generally greater than that found under frost cracks (18 to 31 dm^3 per wound) and mechanical wounds (11 to 30 dm^3 per wound). For broken branches, it becomes difficult to calculate an average unit volume since in many cases areas of trunk decay from several neighboring branches spread into one another.

c) Story of infected trees

On average, 73 percent of the black spruce trees studied showed no decay. From locality to locality, the rot-free percentage ranged from 77 percent in Laurentides Park (locality 2) to 62 percent in Charlevoix (locality 3). In all localities, the trees of the dominant story exhibited decay most often and the volume of decay was greater than in trees

of the lower stories (Table 4). The proportion of trees affected by trunk rot or butt rot is the same in all stories. Thus among rot-infected trees, a greater number exhibit both types of rot in the bottom storey.

During compilation of volumetric data (item 2 of the report), volumes which could not be separated (trunk or butt) were set aside. Accordingly, the total volume of individual instances of trunk or butt rot does not reflect the total volume actually measured in the field and presented in the tables in item two of the report.

d) Other characteristics

Comparison of the incidence and volume of decay from one locality to another (Table 5) would be somewhat difficult because uncontrollable factors (climate, topography, stand history) are in part responsible for the observed

Table 4. Breakdown of decay categories according to story of black spruce in stand (all localities)

Story	Number of trees		Incidence of decay and percentage of of trees infected by decay				Decay volume and percentage of total decay volume				Average volume (dm^3)[a]	
	Total	decay-free (%)	Butt No	Butt %	Trunk No	Trunk %	Butt m^3	Butt %	Trunk m^3	Trunk %	Butt	Trunk
Dominant	1489	928 (62.3)	433	76.0	177	31.5	7.80	19.4	12.27	31.5	18.0	69.3
Co-dominant	1855	1273 (68.6)	431	74.1	183	31.4	3.70	9.1	10.09	25.3	8.6	55.1
Intermediate	1492	1187 (79.4)	238	77.5	84	27.4	1.50	3.7	2.84	7.0	6.3	33.8
Suppressed	1145	943 (82.3)	146	72.3	65	32.1	0.47	1.0	1.22	3.0	3.2	18.8
Total	5981	4331 (72.4)	1248		509		13.47	33.8	26.42	66.2	10.8	51.9

[a] Average volume = decay volume + incidence of decay.

Table 5. Incidence and volume of black spruce decay according to locality

Locality	Number of trees			Incidence of decay				Total decay volume (m^3)		Average decay volume (dm^3)[a]	
	Total	Infected	%	Butt	%	Trunk	%	Butt	Trunk	Butt	Trunk
1	2453	711	29.0	642	26.2	150	6.1	7.0	9.1	10.9	60.3
2	2540	638	25.1	369	14.5	327	12.9	3.0	15.0	8.1	45.9
3	788	303	38.5	326	41.4	42	5.3	3.2	1.7	9.8	40.5

[a] Average volume = total decay volume ÷ incidence of decay.

variations. The available data do not permit analysis of the influence of these factors. It should be noted, however, that in all localities the average decay volumes (trunk and butt) in fertility class II forest types (48 and 10 dm^3 respectively) are larger than those observed in fertility class III forests (27 and 6 dm^3). It was not possible to detect any other significant trend, probably because of the nonsystematic nature of the experimental setup (Table 1).

Volumetric data

The obtained volumetric data come from a virgin forest that had not been managed previously. Tables 6 and 7 provide a summary of the compilations performed on the basis of tree age and diameter from field data. Despite the large number of sample trees in each age class (Table 6), the volume curves derived from these data were oscillatory in form and it was not possible to establish correlation equations.

Since the data compiled in terms of dbh appeared more appropriate and curves based on dbh are more directly used by foresters, the data from Table 7 were used to construct the curves in Figure 2. The estimated values for the average tree in each diameter class are presented in Table 8.

Up to 160 years old, the volumes of decay and cull in black spruce of the boreal forest hover around 4 and 7.5 percent of gross merchantable volume respectively (Table 6). These percentages are encountered when the tree reaches a dbh of 23 cm (Table 8). Beyond this size, the volume of decay grows rapidly, especially once the trunk has attained 32 cm (Figure 2). None the less, net merchantable volume continues to rise even when the tree has reached these sizes.

DISCUSSION AND CONCLUSIONS

The findings concerning the identity and relative importance of the fungi that cause rot in black spruce are consistent with previous reports from studies outside Quebec (Basham 1973b; Basham and Morawski 1964; Etheridge 1956; Whitney 1973). The average decay volume caused by *F. pini* was found to be larger than that caused by *S. sanguinolentum*. At least insofar as advanced decay is concerned, this observation is in keeping with the above-mentioned studies and an earlier study conducted in Quebec (Lavallée 1965). However, on the basis of artificially inflicted wounds studied after two or three years, Whitney and Denyer (1970) and Lachance and Morin (1972) concluded that *S. sanguinolentum* produced large-volume decay more rapidly in black spruce. Other factors such as heartwood moisture content and the size of the original wound are related to the rate at which decay spreads in the tree, but the data from the present study do not permit examination of these factors.

More than 75 percent of the points of entry into the trunk of black spruce trees by major rot fungi result from mechanical wounds, abrasions, or broken branches. In another study (Lavallée 1965), broken crowns were also found to be responsible for penetration of trunk rot. This category of wounds has received more detailed examination in Quebec (Lachance and Morin 1972).

In black spruce as in fir (Lavallée 1986), trunk rot affects larger volumes than butt rot, while the latter is more frequent. The fact that a greater proportion of decay-free trees was found

Table 6. Volume and percentage losses due to decay according to basic field data collected through dissections of black spruce in the boreal forest, by age class

Age class	No of sample trees	Average age	Average height (m)	Average dbh[a] (cm)	Volume (m^3) Total	GMV[b]	Decay	Cull	NMV[c] (decay excluded)	NMV[c] (cull excluded)	Percentage of GMV Decay	Cull
1-20	16	19.4	7.1	8.6	0.34	0.20	0.00	0.02	0.20	0.18	0.0	10.0
21-40	383	27.9	9.3	11.2	17.97	14.66	0.02	0.56	14.64	14.10	0.1	3.8
41-60	620	51.1	11.1	13.0	53.94	47.68	0.26	1.40	47.42	46.28	0.5	2.9
61-80	763	72.1	10.6	12.4	61.27	54.22	1.32	3.45	52.90	50.77	2.4	6.3
81-100	1 746	92.4	13.0	15.7	204.23	188.98	7.83	14.05	181.15	174.93	4.1	7.4
101-120	1 290	109.1	14.8	17.8	258.31	243.76	9.74	18.37	234.02	225.39	4.0	7.5
121-140	535	131.1	14.3	17.0	95.44	89.37	3.73	6.66	85.64	82.71	4.2	7.4
141-160	459	149.7	15.3	18.5	102.03	96.47	3.53	6.83	92.94	89.64	3.7	7.1
161 and +	439	183.9	15.5	20.1	116.00	110.10	7.82	13.83	102.28	96.27	7.1	12.6
Total	5 981				909.53	845.44	34.25	65.17	811.19	780.27		
Average											4.0	7.6

[a] dbh = diameter at breast height (1.3 m above ground level).

[b] Stump and non-merchantable portion of trunk excluded.

[c] NMV = net merchantable volume.

Table 7. Volume and percentage losses due to decay according to basic field data collected through dissections of black spruce in the boreal forest, by dbh class

Dbh class (cm)	No of sample trees	Average age	Average height (m)	Average dbh[a] (cm)	Volume (m^3) Total	GMV[b]	Decay	Cull	NMV[c] (decay excluded)	NMV[c] (cull excluded)	Percentage of GMV Decay	Cull
-9.0	451	66.3	7.4	8.1	8.71	4.51	0.08	0.65	4.43	3.86	1.7	14.4
10.2	915	78.4	9.4	10.2	33.98	25.64	0.57	4.18	25.07	23.46	2.1	8.5
12.7	1 065	91.9	11.3	12.7	74.08	64.71	1.38	3.97	63.33	60.74	2.1	6.1
15.2	1 034	98.6	13.1	15.2	117.62	107.91	2.71	6.49	105.20	101.42	2.5	6.0
17.8	934	107.5	14.7	17.5	157.62	147.79	5.67	10.93	142.12	136.86	3.8	7.2
20.3	650	116.7	16.1	20.1	151.97	144.23	6.00	10.98	138.23	133.25	4.2	7.5
22.9	440	117.5	17.1	22.6	135.26	129.34	5.51	9.84	123.83	119.50	4.3	7.6
25.4	270	126.9	18.1	25.0	105.44	101.26	4.89	8.68	96.37	92.58	4.8	8.6
27.9	148	137.1	19.3	27.7	72.03	69.22	3.32	5.27	65.90	63.95	4.8	7.6
30.5	39	133.2	19.7	30.0	22.57	21.76	1.26	2.00	20.50	19.76	5.8	9.2
31.8 and +	35	160.0	20.9	37.3	30.28	29.08	2.85	4.20	26.23	24.89	9.8	14.4
Total	5 981				909.56	845.45	34.24	65.19	811.21	780.27		
Average											4.0	7.7

[a] dbh = diameter at breast height (1.3 m above ground level).

[b] Stump and non-merchantable portion of trunk excluded.

[c] NMV = net merchantable volume.

Table 8. Average volume (dm^3) per tree and percentage decay and cull in relation to diameter class for black spruce in the boreal forest (estimated values)

Dbh (cm)	No. of trees	Average height (m)	Average age	Volume						Percentage of GMV	
				Total	GMV[a]	Decay	Cull	NMV[b] (decay)	NMV[b] (cull)	Decay	Cull
-9.0	451	7.4	66.3	19.9	10.8	0.3	1.2	10.5	9.6	2.8	11.1
10.2	915	9.4	78.4	36.9	27.9	0.6	2.3	27.3	25.6	2.1	8.2
12.7	1 065	11.3	91.9	68.7	59.6	1.4	4.3	58.2	55.3	2.3	7.2
15.2	1 034	13.1	98.6	112.2	102.6	2.8	7.1	99.8	95.5	2.7	6.9
17.8	934	14.7	107.5	168.9	158.5	4.9	11.2	153.6	147.3	3.1	7.1
20.3	650	16.1	116.7	233.6	221.9	8.0	16.4	213.9	205.5	3.6	7.4
22.9	440	17.1	117.5	310.3	296.9	12.5	23.2	284.4	273.7	4.2	7.8
25.4	270	18.1	126.9	392.4	376.7	18.2	31.3	358.5	345.4	4.8	8.3
27.9	149	19.3	137.1	481.5	463.2	25.8	41.0	437.4	422.2	5.6	8.8
30.5	39	19.7	139.2	580.9	559.1	35.8	53.1	523.3	506.0	6.4	9.5
31.8 and +	35	20.9	160.0	865.2	831.1	75.0	94.8	756.1	736.3	9.0	11.4

[a] Stump and non-merchantable portion of trunk excluded.

[b] NMV = net merchantable volume.

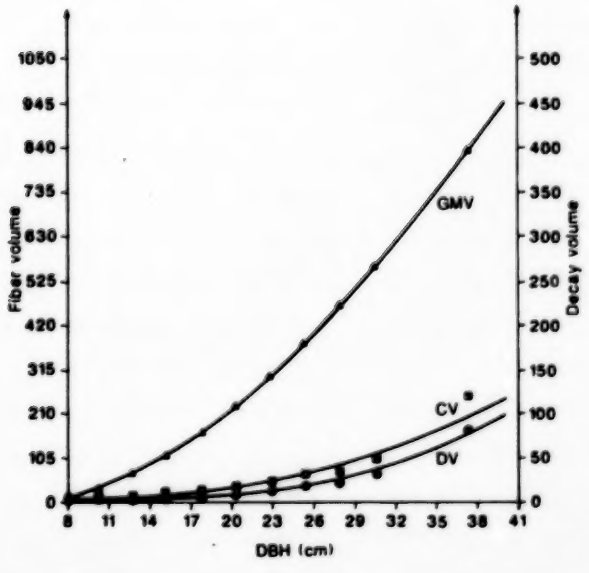

Figure 2. Average volume (dm^3) per tree in relation to diameter (dbh) for black spruce in the boreal forest. Gross merchantable volume (GMV), decay volume (DV), and cull volume (CV).

in the lower story of the black spruce stand indicates that the forest under study had been subject to little treatment or disturbance. With mechanization of cutting, it is probable that the trees exhibit higher incidence of wounds in managed stands.

The limited observations with regard to site fertility are in keeping with conclusions drawn by Whitney and Denyer (1970) to the effect that rot spreads more rapidly in fast-growing trees. The fact that total or average volumes of trunk and butt rot are higher in trees of the upper stories (Table 4) also illustrates this phenomenon. In order to discuss the effect of drainage on the presence and spread of rot, more trees would have to be dissected in poorly drained sites.

Insofar as volumetric figures are concerned, studies of individual trees from different stands cannot be used in terms of area; they are used in relation to age or dbh only. Most previously published decay studies (Morawski et al. 1958; Basham 1973a) indicate good correlation between decay and tree age. The data analyzed for the present study led us to highly variable total or merchantable volumes going from one age class to the next, especially at 100 years and over (Table 6). Several factors may have contributed to this particular state. First, nearly half the trees were selected on the basis of their diameter (Baie-Comeau). Second, the correction factor for determining tree age from age at dbh is more difficult to establish for black spruce than for other coniferous species. Nonetheless, the observed decay and cull percentages in relation to age are in keeping with what has been found for black spruce in Ontario (Morawski et al. 1958). It should also be noted that the cull percentages determined according to current scaling rules would probably be lower than the reported figures since wood processing techniques have improved.

The volumetric figures in terms of dbh can be used as a general information base. If necessary they can be verified at the local level for greater accuracy, but variation between the localities studied was not very large. As an example, for Baie-Comeau, Pomerleau and Morin[1] reported average volumes per infected tree in keeping with those of the present study.

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